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DRIED MILK POWDER IN INFANT FEEDING.[1]

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The infant mortality rate in 573 cities of the United States in 1921 varied from 24 in East Hartford, Conn., to 186 in Dunsmore, Pa., rates which, in addition to heredity and environmental conditions, are largely influenced by nutritional factors.

Various observers working in different communities have reported from 16 to 60 per cent of the children examined by them in the public schools and elsewhere as suffering from defective nutrition. Even if these estimates are only in part true, it is an undeniable fact that an unnecessarily large number of children do not get a fair start in life because of an improperly arranged diet or faulty dietary habits. It is now known that a diet composed of meat, bread, potatoes, and coffee does not supply all of the elements essential to the best development, and that it is necessary to supplement such a diet by the addition of fresh, leafy vegetables and milk in requisite quantity.

Furthermore, it is stated on competent authority that from 75 to 90 per cent of the children of 13 years of age and under have been infected with tuberculosis. It is also believed by many that the infection acquired during childhood may remain quiescent for years without apparent injurious effect and suddenly, as a result of unusual stress or strain, individual resistance is broken down and frank tuberculosis develops. While many factors contribute to this result, it is contended that the vital factor in this breakdown is nutritional, operating not so much because of an insufficiency of food as the failure properly to select and prepare the food comprising the habitual dietary. In other words, defective nutrition may be due not so much to lack of the principal food elements, such as the fats, starches, and proteins, as to a deficiency in the so-called accessory food factors. Nutritional factors, which seem to play a prominent part in the development of tuberculosis, also influence the development of a number of other diseases.

[1] From Field Investigations in Child Hygiene, United States Public Health Service, in cooperation with the Statistical Office, United States Public Health Service.

It is quite evident that any attempt to improve the national health and efficiency must include due consideration of the adequacy of the usual food supply. Owing to the fact that clean, fresh, cow's milk contains all the essential food elements in easily assimilable form, probably the most important nutrition problem is to secure an abundant and safe milk supply at reasonable cost.

From the standpoint of reducing the infant mortality rate and giving the miniature man and woman the best possible start in life, the advocates of preventive medicine have emphasized the importance of breast feeding. However, so many factors contribute toward making breast feeding impossible, undesirable, or neglected, that recourse must be had to substitutes in thousands of cases. Experience and the best medical judgment have confirmed the use of cow's milk as generally the best and most practical substitute for mother's milk. For this reason, measures to increase the quantity and quality of cow's milk at reasonable cost are in line with the best public health opinion and practice. However, despite the wonderful progress made along these lines, the public health official and pediatrist are confronted in many localities with the high cost, with the scarcity, with the impossibility of securing a safe supply, and with the inability of large numbers of householders properly to handle and preserve milk in the home.

Over large areas of our country, cow's milk is not produced in sufficient quantity to supply the local needs. One of the writers has recently visited a State where, in some localities, milk retails at $1 a gallon, obviously beyond the means of a large part of the population. In other sections of this country it is produced in such quantity that much of it goes to waste, because of lack of transportation facilities, the cost of transportation, and the limit to the distance which milk may be transported, the factors of time and temperanture operating to cause deterioration. It is for these reasons that inquiring minds have turned to the solution of these problems and sought to make generally available this valuable food product at reasonable cost. As a result, the dried milk products are coming into wider and wider use.

The value of dried milk as food for adults and older children has been repeatedly demonstrated. In this country, except in institutional cases, no study of any magnitude had been undertaken to establish its usefulness as an exclusive food for infants until that undertaken by the United States Public Health Service in August, 1919, in the city of Boston, in cooperation with the Boston Baby Hygiene Association, the Boston Health Department, and several other agencies. While the Public Health Service had already made some study of the vitamine content and growth-promoting values of dried

milk powder, this study in Boston was designed to determine the safety, usefulness, and comparative value of dried milk powder in infant feeding on a practical, community-wide basis.

The infants included in this study were not specially selected, but represented every type physically, and were recruited from all sorts and conditions of homes. The further requirements were that these infants should be entirely artificially fed, not more than 6 months old, and under the supervision of the Boston Baby Hygiene Association. For purposes of study they were divided into three groups: Group I, children fed on grade "A" milk;[2] Group II, children placed on whole milk powder which was reconstituted in their homes; and Group III, children placed on milk which had been reconstructed from unsalted butter and skimmed milk powder.

Method of preparing milk.—For Group I, the grade "A" milk was modified to meet the age and condition of individual babies.

For Group II an equivalent to 1½ cupfuls (164 grms.) of the whole milk powder was added to 1 quart of cool boiled water. When measured, the powder was dipped from the tin with a large spoon and was not packed down. The powder and the water were thoroughly mixed with an egg beater. The constituents of the mixture approximated: Fat 4 per cent, sugar 5.7 per cent, protein 3.71 per cent. The amount of sugar in such a mixture is about 1 per cent higher than that in grade "A" milk. This fact was taken into consideration when ordering modification with this mixture as a basis.

For Group III the skimmed-milk powder and the sweet butter fat were emulsified by one of the large dairy companies of Boston and distributed to the homes of the children enrolled in this special study. The constituents of the reconstructed milk approximated: Fat 4 per cent, sugar 5.1 per cent, protein 3.1 per cent. The method of modification, consequently, was the same as that for grade "A" milk.

In addition to careful directions for the preparation of milk, the following data were recorded on the history cards of each baby:

1. The weight of the baby at the beginning of the special feeding and at intervals of approximately two weeks thereafter.
2. The strength and amount of feeding, hours of feeding, amount taken in 24 hours, and changes made.
3. The nature and extent of any illness and treatment.
4. General condition of the baby with special reference to character and changes in stools, general development, activity, teething, and disposition.
5. Environment of baby, with special reference to mother's intelligence and cooperation.

[2] Grade "A" milk is an unofficial locally known grade, but special precautions are taken during its production, handling, and distribution. It is pasteurized by the holding process, 145° F. for 30 minutes, at the plant of a large city milk dealer. This milk contains the following constituents. Fat, 4 per cent; sugar, 4.8 per cent; protein, 3.18 per cent. (The bacterial count of this milk ranges between 6,000 and 90,000, averaging 32,000 per c. c.)

In a preliminary report for the first three months during which these investigations were carried on, the results of dried-milk-powder feeding were analyzed in the cases of 287 infants, grouped as follows:

	Number.
Group I—Fed on grade A cow's milk	62
Group II—Fed on whole milk powder	178
Group III—Fed on reconstructed milk	47

The results seem to indicate (1) that the dried-milk powders and their remade products used in this study are safe for infant feeding; (2) that the average gain per baby per day in Group I was 0.629 ounce; in Group II, 0.880 ounce; and in Group III, 0.713 ounce; (3) that the opinions expressed by the nurses engaged in this investigation strengthen the conclusion that the reconstituted and reconstructed milks, of the brand employed, are safe and useful for infant feeding.

In order to evaluate the influence of changing climatic conditions and other factors and to secure additional data as a basis of comparison in respect of the trend of growth of the infants comprising the three groups, it was decided to continue this study for the period of a full year and to include (1) laboratory studies comprising examinations of milk prepared in homes of different degrees of cleanliness; (2) classification of the intestinal flora of a selected number of babies from each group; and (3) careful physical examination of babies of all groups with special reference to the incidence of rickets and scurvy. In addition, studies in the basal metabolism of a number of these babies were made by Dr. Fritz B. Talbot (2), of the Research Laboratory of the Massachusetts General Hospital.

STATISTICAL ANALYSIS OF GROWTH AND OTHER FACTORS.

Number of infants included in the study.—A total of 319 infants were enrolled for the study during the period August, 1919, to October, 1920. Of these, 241 were under observation for a sufficient length of time to furnish reliable data for use in tabulation of weights. No infant was included in the tabulation of results unless there was a record of weighings for at least four weeks. However, in a great majority of instances the weight records extended over a longer period. The number of infants included in each diet group is shown in Table I.

TABLE I.—*Total number of infants included in the feeding experiment and number whose records were utilized in the present tabulation in each diet group.*

	All diet groups.	Diet Group I.	Diet Group II.	Diet Group III.
Total infants enrolled for the experiment between August, 1919, and October, 1920	319	71	194	54
Infants taken off the experiment between August, 1919, and October, 1920 [1]	213	47	129	37
Infants on experimental diets 4 weeks or more between August, 1919, and October, 1920, whose records are utilized in this tabulation	241	63	138	40

[1] The following is a list of the babies who were discharged from this study and the reasons therefor:

	Group I.	Group II.	Group III.	Total.
Taken off because of age and diet	23	27	10	60
Taken off by "private" physicians		24		24
Taken off because families moved	14	15	6	35
Taken off by mothers	3	19	10	32
Taken off by hospitals	2	11	1	14
Taken off by conference doctors		16	10	26
Taken off because of lack of cooperation		9		9
Taken off because breast-milk returned and artificial feeding was no longer necessary		1		1
Died	5	7		12
Total	47	129	37	213

Of the 26 taken off by conference physicians, 5 had diarrhea, 4 had persistent vomiting, 16 failed to gain satisfactorily, and 1 had obstinate constipation.

Of the 26 taken off by conference physicians, 13 began to improve at once on natural milk, 6 showed fluctuating results for several weeks and then improved, 4 showed no improvement, 2 moved and follow-up work was impossible, and 1 developed tuberculosis (mother had died of this disease).

Following are the causes of death:

Cause.	Group I.	Group II.	Group III.	Total.
Diarrhea	2	3		5
Pneumonia	2	3		5
Acidosis		1		1
Diphtheria	1			1
Total	5	7		12

Two other deaths not included in this list occurred during the course of the demonstration. In both cases the babies had been on the powder only a few days and died from causes not attributable to feeding. They are recorded among those taken off by "private" physicians.

A larger number of infants were included in Group II, which comprised the children fed on reconstituted whole milk powder. Considerable difficulty was experienced in gaining the consent of mothers to place infants on reconstructed milk made from the skimmed milk powder and butter fat, which accounted for the relatively few infants included in Group III. This was due largely to two causes: In the first place to the necessity at the beginning of the study of educating the mothers to the use of this new variety (to them) of infant food, and in the second instance to the difficulty experienced in securing a perfect emulsion, a thin float of fat rising on the surface of the milk in the necks of the bottles. Although the fat lost was compensated for, still the appearance of the milk excited apprehension on the part of the mothers.

Age distribution.—With a few exceptions, no infants were included in this study who were over 6 months of age at the time they were put on the special diets. However, in the calculation of weights, no record was tabulated after the infant had reached 10 months of age or if it had begun to receive a mixed diet before reaching the age of 10 months. The number of infants in monthly age groups was so small that for the purpose of comparison they were combined with groups comprising infants of 1, 2, and 3 months of age, and of 4, 5, and 6 months of age.

TABLE II.—*Distribution according to age of infants on the experimental diets, by diet groups.*

Age in months.[1]	Number of infants.				Percentage of infants each month of age.			
	All diet groups.	Diet Group I.	Diet Group II.	Diet Group III.	All diet groups.	Diet Group I.	Diet Group II.	Diet Group III.
All ages	241	63	138	40	100.0	100.0	100.0	100.0
1	40	12	20	8	16.6	19.1	14.5	20.0
2	53	21	29	3	22.0	33.3	21.0	7.5
3	47	12	27	8	19.5	19.1	19.6	20.0
4	36	6	24	6	14.9	9.5	17.4	15.0
5	42	6	29	7	17.4	9.5	21.0	17.5
6	23	6	9	8	9.6	9.5	6.5	20.0
1 to 3, inclusive	140	45	76	19	100.0	100.0	100.0	100.0
1	40	12	20	8	28.6	26.7	26.3	42.1
2	53	21	29	3	37.8	46.6	38.2	15.8
3	47	12	27	8	33.6	26.7	35.5	42.1
4 to 6, inclusive	101	18	62	21	100.0	100.0	100.0	100.0
4	36	6	24	6	35.6	33.3	38.7	28.6
5	42	6	29	7	41.6	33.3	46.8	33.3
6	23	6	9	8	22.8	33.3	14.5	38.1

[1] Classified according to the nearest month of age.

In each case the percentage seems to indicate a fairly similar age distribution in each diet group. The data seem reasonably comparable for 3-month age groups and, with broad limitations, fairly comparable for the total groups of all ages.

Seasonal distribution.—In order to evaluate the effect of change in climatic conditions, 241 infants observed during the period August, 1919, to October, 1920, were tabulated according to the month in which they were put on the several diets, and a study of the percentages for each month showed that the distribution of the infants between the different months of the year was not markedly dissimilar in the three feeding groups. The seasonal elements, therefore, should have affected the average growth of the infants in each group in approximately the same degree.

Physical condition.—Practically 80 per cent of the infants included in the statistical study of this demonstration were given at least one

thorough physical examination by a physician at some time during the period of investigation. Approximately one-half of the infants examined were given more than one examination to determine any change in the physical condition since the previous examination. Each child examined was rated as in "good," "fair," or "poor" physical condition. These ratings were made on the basis of the child's physical make-up rather than on the temporary condition existing at the time of the examination. That is, an infant having diarrhea at the time of examination was rated as "good" in spite of this handicap, provided his general physical condition warranted such rating.

TABLE III.—*Distribution according to physical condition of the infants who were examined at least once during the experiment, by diet and age groups.*

Age group and physical condition.	Number of infants.				Percentage of infants in each physical condition.			
	All diet groups.	Diet Group I.	Diet Group II.	Diet Group III.	All diet groups.	Diet Group I.	Diet Group II.	Diet Group III.
All ages:								
Total examined	192	46	119	27	100.0	100.0	100.0	100.0
Good	65	18	39	8	33.9	39.1	32.8	29.6
Fair	116	24	73	19	60.4	52.2	61.3	70.4
Poor	11	4	7	0	5.7	8.7	5.9	.0
1-3 months, inclusive:								
Total examined	108	29	65	14	100.0	100.0	100.0	100.0
Good	41	12	21	8	38.0	41.4	32.3	57.1
Fair	58	14	38	6	53.7	48.3	58.5	42.9
Poor	9	3	6	0	8.3	10.3	9.2	.0
4-6 months, inclusive:								
Total examined	84	17	54	13	100.0	100.0	100.0	100.0
Good	24	6	18	0	28.6	35.3	33.3	.0
Fair	58	10	35	13	69.0	58.8	64.8	100.0
Poor	2	1	1	0	2.4	5.9	1.9	.0

It may be observed that over 90 per cent of the infants in each diet group were rated as either in "fair" or "good" physical condition. This is a very satisfactory showing, especially in view of the fact that the number of infants examined had been on these special diets for a considerable length of time prior to the physical examination.

Morbidity.—Owing to the fact that the number of infants in any particular age group was not large, it was deemed inadvisable to subdivide these groups into the well and sick, because of the unreliability of results based on a small number of cases which would have resulted from such classification.

TABLE IV.—*Cases of illness occurring among infants on the experimental diets, and the rate per 1,000 infants, by diet groups.*[1]

Disease.	Cases of illness.				Cases of illness per 1,000 infants.			
	All diet groups.	Diet Group I.	Diet Group II.	Diet Group III.	All diet groups.	Diet Group I.	Diet Group II.	Diet Group III.
All illness	146	37	82	27	458	521	423	500
Diarrhea	80	19	50	11	251	268	258	204
All illness other than diarrhea	66	18	32	16	207	254	165	296
Whooping cough	18	7	9	2	56	99	46	37
Pneumonia	17	5	7	5	53	70	36	93
Bronchitis	12	1	6	5	38	14	31	93
Measles	8	2	5	1	25	28	26	19
Influenza	3	1	1	1	9	14	5	19
Chicken pox	2	1	1	0	6	14	5	0
Meningitis	2	0	2	0	6	0	10	0
Mumps	1	0	0	1	3	0	0	19
Diphtheria	1	1	0	0	3	14	0	0
Tonsilitis	1	0	0	1	3	0	0	19
Acidosis	1	0	1	0	3	0	5	0

[1] Based on a total of 319 infants on experimental diets during the experiment: Group I, 71; Group II, 194; Group III, 54.

As shown in the above tables the physical condition and sickness among the infants of the three diet groups was sufficiently similar to render them reasonably comparable. In other words, the physical condition as revealed by medical examination was rated so high in such a large percentage of cases that the influence of intercurrent sickness was considered negligible in calculating the effect of special diets on growth as measured by gain in weight.

Effect on growth.—Gain in weight alone may not be considered sufficient evidence on which to base final conclusions relative to the values of the special diets prescribed in these studies. However, it probably offers the most reliable index for mathematical demonstration, especially when taken in connection with observations of the general development, activity, and disposition of individual infants.

In determining the average weights, the infants were classified in two age groups, those 1 to 3 months of age, inclusive, and those 4 to 6 months, inclusive, at the time they began on the special diets. All physical conditions were included in each age group. The small numbers, especially in diet Groups I and III, made it inadvisable to further subdivide the data.

Table V.—*Number of infants (all ages), mean weights, and indices of weights for each week under observation, by diet groups.*

Weeks under observation.	Number of infants on each diet.			Mean weights, in pounds, of infants on each diet.			Indices of mean weights of infants.[1]		
	Diet Group I.	Diet Group II.	Diet Group III.	Diet Group I.	Diet Group II.	Diet Group III.	Diet Group I.	Diet Group II.	Diet Group III.
Beginning	63	138	40	9.95	10.00	10.95	100.0	100.0	100.0
1	63	138	40	10.26	10.42	11.38	103.1	104.0	103.7
2	63	138	40	10.57	10.77	11.72	106.1	107.7	107.0
3	63	138	40	10.84	11.12	12.05	109.0	111.1	110.2
4	63	138	40	11.13	11.44	12.44	112.0	114.4	113.7
5	63	138	39	11.45	11.77	12.85	115.1	117.8	117.1
6	63	133	38	11.76	12.14	13.16	118.2	121.2	119.8
7	63	126	35	12.03	12.44	13.35	121.1	124.6	122.1
8	63	123	30	12.33	12.81	13.60	123.7	127.8	125.0
9	60	120	28	12.54	13.08	14.13	126.3	130.9	128.6
10	60	116	28	12.84	13.38	14.50	129.0	134.2	132.0
11	60	109	28	13.14	13.79	14.73	131.6	137.6	134.8
12	57	108	25	13.30	14.11	15.06	134.5	141.0	137.0
13	55	107	24	13.71	14.41	15.22	136.7	144.0	139.0
14	53	102	22	13.80	14.67	15.38	139.3	146.9	140.5
15	52	99	21	14.06	14.98	15.55	141.6	149.8	142.4
16	51	90	21	14.40	15.28	15.83	144.2	152.4	144.6
17	45	87	20	14.59	15.45	16.11	146.7	155.0	146.8
18	44	85	20	14.80	15.77	16.26	147.9	157.6	148.2
19	42	79	18	14.77	16.07	16.32	149.8	160.5	148.8
20	40	73	16	15.15	16.32	16.28	150.9	162.4	150.0
21	37	69	14	15.11	16.34	16.68	152.7	164.4	150.8
22	37	61	11	15.32	16.67	16.56	154.0	166.2	152.4
23	35	54	9	15.53	16.85	16.83	155.7	168.7	152.9
24	34	47	8	15.62	17.09	16.82	156.4	170.7	154.4
25	32	39	6	15.53	17.28	17.07	156.2	172.6	156.9
26	29	36	5	15.46	17.41	17.65	156.2	174.7	159.9
27	29	33	5	15.63	17.73	17.81	156.9	177.2	161.6
28	28	26	....	15.73	18.01	....	158.7	178.9	....
29	22	19	....	16.01	17.92	....	161.4	180.0	....
30	20	18	....	16.43	18.06	....	164.5	180.6	....
31	20	17	....	16.68	18.19	....	166.6	181.4	....
32	18	15	....	16.63	18.17	....	167.2	183.5	....
33	17	12	....	16.60	18.70	....	166.6	187.1	....
34	15	10	....	16.50	19.25	....	166.8	191.8	....
35	13	10	....	16.70	19.59	....	167.5	195.5	....

[1] Computed from a 3-week moving average.

Table V shows by diet groups the number of infants under observation each week, the average weight of each group for each week, and a series of weekly index numbers of the average weights.[3] Tables VI

[3] In order to obtain a series of weekly weights for each of the three groups, the following procedure was employed: After combining the individuals into special groups for comparison (according to kind of diet, age, etc.), the recorded weights for each infant were plotted, using as abscissæ the number of days the child had been on the specified diet. Thus, in the case of each infant, the date on which it was put on the diet was plotted as 0, the second day 1, the third 2, and so on. A curve (smoothed by inspection, but plotted through each point) was then drawn for each infant. The weights at the end of each seven-day period were then read from these curves, added together for each group of individuals, and the arithmetic mean computed. The resulting figures are a series of weekly average weights for the various groups based on the individual curves derived from the somewhat irregular record for each infant. The facts that in the majority of instances the weighings were quite frequent and at fairly regular intervals, and that a remarkably smooth series of group curves was finally obtained, afford reasonably certain grounds for believing that a fairly accurate series of group pictures of the growth of the infants was obtained.

Although a considerable number of infants were taken off the experimental diets during the course of the study, it is believed that those remaining in any given diet group did not constitute a selected class

and VII show the same data for the two subgroups—the infants 1 to 3 months of age, inclusive, and those 4 to 6 months of age, inclusive.

Table VI.—*Number of infants 1 to 3 months of age (inclusive), mean weights, and indices of weights for each week under observation, by diet groups.*

Weeks under observation.	Number of infants on each diet.			Mean weights, in pounds, of infants on each diet.			Indices of mean weights of infants.[1]		
	Diet Group I.	Diet Group II.	Diet Group III.	Diet Group I.	Diet Group II.	Diet Group III.	Diet Group I.	Diet Group II.	Diet Group III.
Beginning	45	76	19	8.82	8.48	9.26	100.0	100.0	100.0
1	45	76	19	9.13	8.84	9.64	103.4	104.0	104.0
2	45	76	19	9.41	9.15	9.99	106.6	108.1	107.7
3	45	76	19	9.66	9.51	10.29	109.6	112.0	111.7
4	45	76	19	9.94	9.84	10.74	112.8	116.0	116.4
5	45	76	18	10.24	10.17	11.32	116.1	120.0	121.1
6	45	72	17	10.53	10.53	11.58	119.3	124.1	125.3
7	45	69	16	10.80	10.85	11.90	122.4	128.3	128.5
8	45	66	15	11.07	11.27	12.23	125.4	132.5	132.9
9	43	65	13	11.31	11.60	12.79	128.6	136.4	137.6
10	43	63	13	11.63	11.83	13.19	131.7	140.4	142.0
11	43	58	13	11.93	12.30	13.48	135.0	144.6	145.2
12	42	57	12	12.17	12.65	13.67	138.5	148.9	148.3
13	40	56	12	12.55	12.95	14.04	141.7	152.4	150.1
14	40	55	11	12.78	13.16	13.99	144.9	156.0	152.5
15	39	54	11	13.01	13.57	14.34	148.0	159.3	154.9
16	38	50	11	13.37	13.81	14.69	151.6	163.2	158.4
17	34	50	10	13.74	14.14	14.99	155.3	167.0	161.4
18	34	49	10	13.99	14.52	15.18	158.4	171.5	162.6
19	34	45	9	14.18	14.97	15.01	161.6	175.7	163.5
20	32	40	9	14.58	15.20	15.23	164.1	179.4	166.7
21	30	40	8	14.64	15.47	16.09	166.4	183.3	171.5
22	30	37	8	14.82	15.96	16.31	168.1	187.4	177.0
23	30	36	7	15.04	16.25	16.76	170.6	191.9	179.3
24	30	34	6	15.28	16.61	16.73	172.8	195.2	182.1
25	29	31	4	15.39	16.78	17.08	174.3	198.2	184.3
26	27	29	4	15.45	17.04	17.41	175.6	201.4	187.5
27	27	27	4	15.62	17.43	17.58	177.1	205.4	189.4
28	27	22	4	15.79	17.80	17.63	179.3	209.0	190.5
29	22	19	4	16.01	17.92	17.70	182.3	211.4	191.1
30	20	18	4	16.43	18.06	17.77	185.6	213.0	195.9
31	20	17	....	16.68	18.19	....	188.0	213.9	....
32	18	15	....	16.63	18.17	....	188.7	216.4	....
33	17	12	....	16.60	18.70	....	188.0	220.6	....
34	15	10	....	16.50	19.25	....	188.2	226.2	....
35	13	10	....	16.70	19.59	....	189.0	230.5	....

[1] Computed from a 3-week moving average.

which was not comparable to the other groups. This belief is strengthened by the fact that the weight curves (indices of weights) diverge consistently even during the first four weeks under observation, during which time the numbers of infants on each given diet remained the same. Infants who did not remain on the diet at least four weeks were not included, since the time seemed insufficient to judge the effect of the diet.

It was noted that there were a few irregularities in the average weights, especially in Group III, which contained the smallest number of infants. In order to eliminate these irregularities, a moving average was computed. A three-week period was used in order that significant changes would not be obscured. For the purpose of facilitating the comparison of the average weights for the three diet groups indices were computed on the smoothed weights for each group. The average weight at the beginning was used as the base, since it was the starting point of different diets and would therefore be the starting point of any diverging rates of growth which might result.

Table VII.—*Number of infants 4 to 6 months of age (inclusive), mean weights and indices of weights for each week under observation, by diet groups.*

Weeks under observation.	Number of infants on each diet.			Mean weights, in pounds, of infants on each diet.			Indices of mean weights of infants.[1]		
	Diet Group I.	Diet Group II.	Diet Group III.	Diet Group I.	Diet Group II.	Diet Group III.	Diet Group I.	Diet Group II.	Diet Group III.
Beginning	18	62	21	12.77	11.87	12.48	100.0	100.0	100.0
1	18	62	21	13.10	12.36	12.96	102.7	103.9	103.4
2	18	62	21	13.47	12.75	13.29	105.3	107.3	106.6
3	18	62	21	13.77	13.10	13.65	108.0	110.2	109.3
4	18	62	21	14.13	13.39	13.98	110.6	113.0	111.6
5	18	62	21	14.46	13.73	14.17	113.4	115.6	113.8
6	18	61	21	14.84	14.04	14.45	116.2	118.3	115.4
7	18	57	19	15.22	14.35	14.57	118.9	120.7	117.5
8	18	57	15	15.49	14.61	14.97	121.0	123.0	119.7
9	17	55	15	15.63	14.83	15.29	122.7	125.4	122.6
10	17	53	15	15.90	15.22	15.63	124.5	127.9	124.8
11	17	51	15	16.18	15.49	15.82	126.7	130.4	127.6
12	15	51	13	16.45	15.74	16.35	129.1	132.7	129.7
13	15	51	12	16.82	16.01	16.41	131.0	135.3	132.3
14	13	47	11	16.92	16.44	16.76	133.0	137.9	133.7
15	13	45	10	17.21	16.67	16.89	134.5	141.0	135.5
16	13	40	10	17.39	17.12	17.08	135.2	143.2	136.8
17	11	37	10	17.22	17.22	17.23	136.1	145.5	137.9
18	10	36	10	17.53	17.47	17.33	135.8	146.7	139.4
19	8	34	9	17.26	17.53	17.63	136.3	147.9	140.5
20	8	33	7	17.45	17.68	17.63	135.3	148.2	140.9
21	7	29	....	17.14	17.55	....	135.9	148.8	....
22	7	24	....	17.46	17.76	....	138.6	149.9	....
23	....	18	....	....	18.05	....	....	152.1	....
24	....	13	....	....	18.34	....	....	156.1	....

[1] Computed from a 3-week moving average.

Figure I shows by diet groups the indices of the mean weights of infants of all ages and in each of the age groups used. All three charts are drawn on logarithmic scale and, therefore, show the proportional increase in mean weight in each diet group.

In all age classes, the infants fed on a modification of cow's milk (Group I) made distinctly less progress, as measured by gain in weight, than those fed on a modification made from whole-milk powder. This difference was especially marked in the younger group (1 to 3 months). For example, the average weights of infants in the one to three months of age class at the beginning of the special feeding was 8.82, 8.48, and 9.26 pounds for Groups I, II, and III, respectively, and in the fourth week the average weights were 9.94, 9.84, and 10.74 pounds, with indices of 112.8, 116.0, and 116.4. In the twenty-fourth week the average weights for each group was 15.28, 16.61, and 16.73 pounds, with indices of 172.8, 195.2, and 182.1, respectively.

The infants fed on a modification reconstructed from unsalted butter and skimmed-milk powder (Group III) increased less rapidly in weight in the older age group (4 to 6 months) and in the total group (all ages), but in the younger age group (1 to 3 months) the

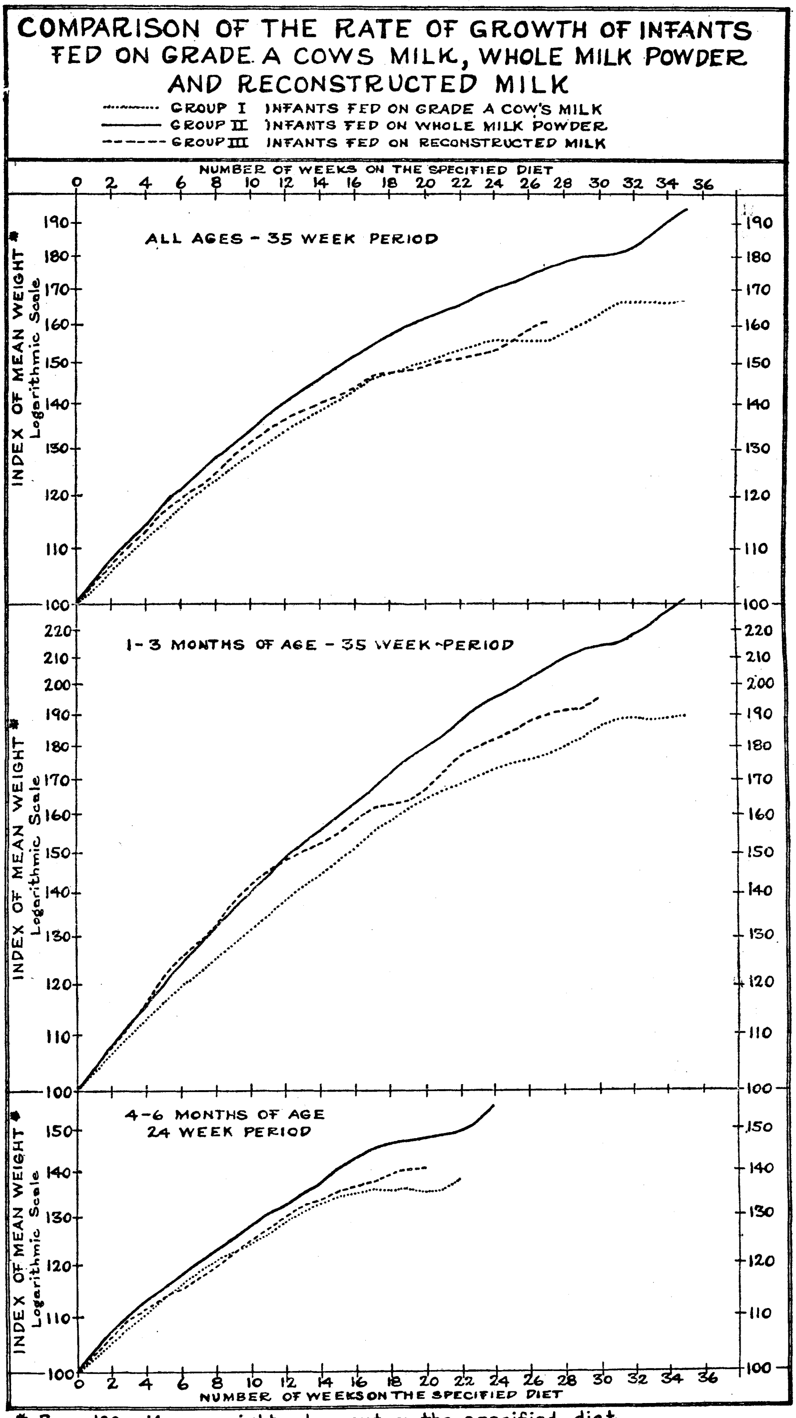
COMPARISON OF THE RATE OF GROWTH OF INFANTS FED ON GRADE A COWS MILK, WHOLE MILK POWDER AND RECONSTRUCTED MILK
GROUP I INFANTS FED ON GRADE A COW'S MILK
GROUP II INFANTS FED ON WHOLE MILK POWDER
GROUP III INFANTS FED ON RECONSTRUCTED MILK
NUMBER OF WEEKS ON THE SPECIFIED DIET
ALL AGES - 35 WEEK PERIOD
1-3 MONTHS OF AGE - 35 WEEK PERIOD
4-6 MONTHS OF AGE
24 WEEK PERIOD
INDEX OF MEAN WEIGHT *
Logarithmic Scale
NUMBER OF WEEKS ON THE SPECIFIED DIET
* Base 100 = Mean weight when put on the specified diet

FIGURE 1.

gain in weight closely approximated that of the infants on whole-milk powder (Group II) for about 11 weeks, but after the twelfth week on this diet the rate decreased and the curve approaches that of Group I.

Since the weight curves for Group I are consistently below those for Group II in all three age classes, it seems safe to conclude that the infants on whole milk powder gained in weight more rapidly than did those fed on cow's milk. However, in regard to Group III, where the number of infants under observation was small and the weight curves do not show as consistent variations, no definite conclusions can be drawn from the statistical data.

LABORATORY STUDIES.[4]

In addition to careful studies in metabolism, rate of gain in weight, and the physical development of the babies included in this study, bacteriological investigation of the intestinal flora was undertaken.

From a technical standpoint these studies should properly have been made in an institution to insure complete control of the diet; but it was found to be impossible to secure institutional accommodations for babies in sufficient number to give reliable statistical results. For this reason it was necessary to visit the homes in order to obtain fresh specimens of infants' stools. The specimens of stools were collected between 8 and 10 o'clock in the morning, by an assistant who visited each house. A glass tube about one-half centimeter in diameter was removed from a sterile test tube, inserted in the rectum, and then returned to the test tube and placed in a container with ice until examined.

The results of this study are based on 110 specimens, received from 24 babies through a period of 10 weeks. The maximum number of times specimens were obtained from the same baby was 7, and the average number was 4.6. No data were included in calculations in the case of babies from whom specimens had been obtained less than twice.

Specimens from two breast-fed babies were used as controls, which formed an interesting comparison with the groups fed on grade A milk, the whole milk powder, and emulsified milk, respectively.

Effect on the intestinal flora.—According to Kendall (3) the substitution of cow's milk for human milk causes *B. bifidus* to tend to disappear. Porter (4) also calls attention to the antagonism between the acidophilic flora produced under human milk and other high sugar feedings, and the alkali-loving proteolyzers that inhabit the intestinal tract of children taking cow's milk or other foods high in animal protein.

[4] Space for these bacteriological studies was set aside in the laboratories of the Harvard Medical School through the courtesy of Prof. M. J. Rosenau, whose advice and assistance in this work were of great value.

In these studies it was found that the substitution of powdered milk for ordinary cow's milk causes the gram positive bacilli to tend still further to disappear. In this respect the emulsified milk causes the same effect as the whole milk powder, the difference being but 0.5 per cent.

TABLE VIII.—*The average percentage bacterial count of smears from "stock dilution" of stools.*

	Breast-fed.	Grade "A" (Group I).	Whole-milk powder (Group II).	Emulsified milk (Group III).
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Gram negative organism	7	23.2	24.5	24.2
Gram positive organism	93	76.8	75.5	76.8
Gram positive rod	97.5	54.7	43.6	42.1
Gram positive coccus	2.5	45.3	56.4	57.9

A study of the total count of the microorganisms in the stools shows the lowest count for the breast-fed babies, with Group II (receiving whole-milk powder) second.[5]

TABLE IX.—*Average of total counts of microorganisms.*

	Number per mg.
Breast-fed	324,000
Group II, whole-milk powder	980,000
Group I, grade "A"	1,130,000
Group III, emulsified	1,140,000

The groups fed with milk handled commercially manifested a tendency to a group rise in total count of microorganisms during a hot week, while the whole-milk powder group showed a scattered rise. This would seem to indicate that the babies fed a milk prepared in the home under reasonable precautions had greater chances of escaping digestive disturbances during hot weather than those receiving a dairy-handled product.

Bacterial count of the several milks used.—A freshly opened can of whole-milk powder had a count of 1,600 per c. c. when made up. Skimmed-milk powder showed a count of 27,000 under the same conditions. Unsalted butter had a count of 1,900,000 microorganisms, showing that the product as furnished to the baby is much higher in bacterial content than whole-milk powder. During the hot days the count for grade "A" milk ran as high as 200,000 per c. c., and the count for emulsified milk as high as 100,000 per c. c.

Effect of holding and of the addition of lactose on the bacteriological content.—It seemed desirable to determine the rise in the bacteriologi-

[5] It is worthy of note that the prepared food which was shown in the laboratory to be lowest in bacterial count is the same which was fed to the group showing the lowest total count of the stool (breast-fed babies not considered).

cal count after holding the various milks for stated periods. Studies were also made to determine whether or not raising the percentage of lactose in these milks exercised any effect on the bacteriological content. It was found that the lactose played little, if any, part in the keeping qualities of these milks, while the effect of holding at 30° C. for seven hours is marked.

TABLE X.—*Showing the effect of adding lactose and of "holding"—Counts of micro-organisms.*

	Whole milk powder (Group II).	Grade "A" milk (Group I).	Emulsified milk (Group III).
1. Without lactose, plated directly	1,300	68,000	99,000
2. With lactose, plated directly	1,300	79,000	108,000
3. No lactose, held 7 hours at 30° C.	87,000	19,000,000	28,000,000
4. With lactose, held 4 hours at 30° C.	89,000	19,000,000	28,000,000

From the bacteriological standpoint it would seem that powdered milk, and especially the whole milk powder, can be safely used for feeding infants where a good grade of fresh cow's milk can not be obtained.

THE RELATION OF DRIED MILK TO SCURVY.

The relation of dried milk to scurvy is dependent upon the antiscorbutic vitamine content of the particular dried milk in question. Dried milks, like fresh milks, vary considerably in this respect. The observations of Hopkins, Chick, Hume, Skelton, and Barnes (5, 6, 7) led to the conclusion that the amount of vitamine C (the antiscorbutic vitamine) even in fresh milk is not large, but is sufficient to protect from scurvy, and has even some curative value if given in suitable quantity (7, 8, 9). An infant requires at least 1 pint, or about 500 c. c., of fresh raw milk daily to protect it from scurvy (10, 11). But the variation of milk in respect of vitamine must be taken into consideration. It appears to be definitely established that the diet of the cow has a marked effect upon the antiscorbutic content of her milk (12, 13, 14), and it follows that summer milk from pasture-fed cows has the higher value. It is stated that 20 c. c. of summer milk is better than 60 c. c. of winter milk (12). Fresh summer milk, used soon after it is drawn, has definite antiscorbutic value. It has been very generally believed that the process of drying milk reduces or destroys its antiscorbutic value, and it is probably safer, in infant feeding, to proceed on this assumption and adhere closely to the policy of including an additional antiscorbutic in the dietary. Hess, however, states that drying does not necessarily destroy the antiscorbutic factor (15, 16), and Rosenau has more

recently expressed the same opinion (17). To obtain a dried milk of highest antiscorbutic value, it is necessary that the milk to be used should be fresh and of high antiscorbutic value, exposed to a high temperature for not longer than one minute, protected from light, air, and alkalinization, and used within a few months of the time of manufacture.

The mothers of infants under the supervision of the Boston Baby Hygiene Association are, as a routine procedure, instructed regarding the use of orange juice in feeding babies and advised to begin the administration at an early age. Thirteen of the babies included in the study failed, for various reasons, to get orange juice, and two of them developed symptoms of scurvy—one an infant on grade "A" milk (Group I), and one on reconstructed milk (Group III). These cases were quickly detected and responded promptly to treatment. Owing to the many factors affecting the antiscorbutic potency of milk, it is good pediatric practice to prescribe orange juice for infants fed on any kind of heated milk.

THE RELATION OF DRIED MILK TO RICKETS.

The relation of diet to the development of rickets is far less simple and clear-cut than its relation to scurvy. Winfield observed no greater liability to rickets in infants fed on dried milk than on fresh milk (18). If the milk is dried by a very rapid process, the calcium salts are probably but little affected, since it has been noted that their precipitation depends upon the length of time the milk is heated (19). Vitamines A and B are considered to be of almost equal value in dried and fresh milk (10, 19, 20, 21, 22). In 1918 Hume (24) stated that fresh milk, butter, and cod-liver oil are the best available preventives of rickets. The next year Mellanby's (24, 25) investigations suggested the possibility that rickets is a true deficiency disease due primarily to a lack of the fat-soluble vitamine. Hopkins and Chick (6) supported this view and went so far as to call fat-soluble A the antirachitic factor. The Medical Research Council (22) in its 1919 report also gave favorable consideration to this theory. In the following year (1920), however, Hess (26), Hess and Unger (27), and McCollum, Simmonds, and Parsons (28) expressed the opinion that rickets is not a deficiency disease in the sense that it is due to the absence of a specific vitamine in the diet. Hess and Unger called attention to the fact that infants on a diet containing large quantities of milk rich in fat-soluble vitamine, as well as protein and salts, frequently develop rickets. In a communication published in 1920 Mellanby (29) observed that the balance between the other elements of the diet, as well as the accessory food factors, is of importance in the development of rickets. Hess (16) in 1921 gave a preliminary

report of some work in infant feeding which seems to show conclusively that the fat-soluble vitamine as it exists in milk is not the antirachitic factor. The recent observation of Paton and Watson (30) supports the view of Hess. McCollum and his colleagues (31) have very recently (June, 1922) published the results of experiments which differentiate between vitamine A and a vitamine which promotes calcium deposition. It seems that neither dried nor fresh milk can be considered a determining factor, as far as can be at present determined, in the prevention of rickets. Its value in this disease may be looked upon as due to its general value as a foodstuff.

A complete physical examination was made of 200 infants enrolled in this study and particular attention was paid to the incidence of rickets. One of the important points brought out by these examinations is the frequency and the similar distribution of this disorder in the different feeding groups. However, a number of these infants undoubtedly presented a slight degree of rickets at the time of enrollment; but owing to the relatively short period of observation in individual cases it is impossible to state with positiveness the effect of dried milk feeding on the course of the disorder.

In this connection it is important to note that the infants studied were recruited from homes of varied economic and hygienic status and fed on milk products containing fat in the usual percentage, which seems to indicate that other factors than a deficiency in the fat-soluble vitamine must be taken into consideration in any attempt to determine the true cause of rickets.

In conclusion, it can be said that the results of this more extended study tend to confirm the conclusions in the preliminary report, which were based on observations extending over a period of relatively short duration, that the dried milk powders and their remade products used in this study are safe for infant feeding, and in some cases seem to have distinct therapeutic value.

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THE TANNIC ACID METHOD FOR QUANTITATIVE DETERMINATION OF CARBON MONOXIDE IN THE BLOOD.[1]

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INTRODUCTION.

Carbon monoxide may occur in many places, and inhalation of that insidious gas is a frequent and widely distributed cause of poisoning, ranging in severity from headache and inefficiency to unconsciousness and death. People are continually being affected by carbon monoxide in the home, in garages, around gas and gasoline engines and blast furnaces, in fighting fires, after blasting in mines and quarries, and after mine fires and explosions; in fact, everywhere there is the possibility of an exposure to the products of combustion of carbonaceous fuels or products. On the other hand, there are many cases reported where ill effects and accidents are wrongly attributed to carbon monoxide. Therefore it is essential for doctors, coroners, safety engineers, and first-aid men to be able to recognize this poisoning, not only in order to give proper treatment and to determine the cause of death, but also to insure just decisions on claims and to eliminate illusions and complaints of workmen.

As the ordinary symptoms of carbon monoxide poisoning, such as headache, nausea, dizziness, collapse, and unconsciousness, can be caused by other things, and may also vary with the individual, there is no specific test for the degree of poisoning except an examination of the blood for carbon monoxide-hemoglobin (CO–Hb) content. To make this test from a purely qualitative consideration is comparatively easy, and a number of procedures have been devised. However, in view of the fact that the occurrence of symptoms is in proportion to the degree of poisoning, it is desirable not only to detect the presence of the CO–Hb, but also to determine the quantity. Heretofore the methods used to make this quantitative estimation have either required elaborate and expensive apparatus, or involved technique unsuited for conditions except those found in the laboratory. Owing to the fact that most of the cases of poisoning occur at places distant from laboratories making these examinations, and also to the obvious necessity of immediate results, there is a demand for a reliable method which can be used by any person likely to have

[1] Investigations carried on in cooperation with the United States Bureau of Mines.